NARSTO & the PM Assessment

PM$_{2.5}$ and Electric Power Generation Conference

April 9, 2002

Pittsburgh, PA

Jim Vickery, Marjorie Shepherd, Peter McMurry
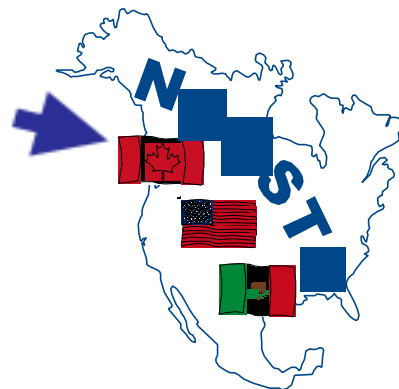
Assessment Co-Chairs
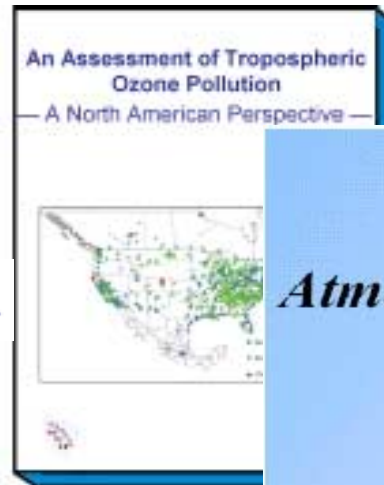
NARSTO,
who we are and what we do

RETHINKING THE OZONE PROBLEM IN URBAN AND REGIONAL AIR POLLUTION
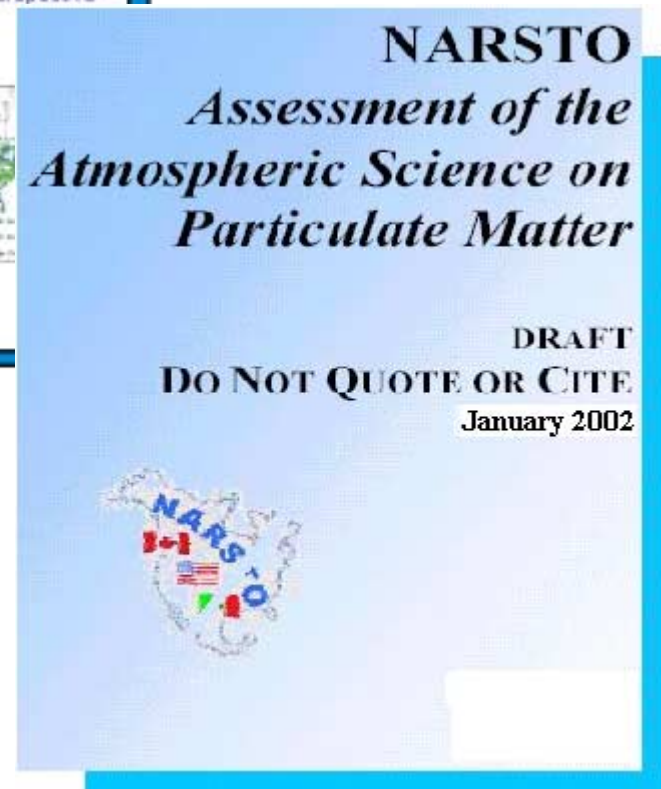
NRC

1991

1995

An Assessment of Tropospheric Ozone Pollution
— A North American Perspective —

2000

NARSTO
Assessment of the Atmospheric Science on Particulate Matter

DRAFT
DO NOT QUOTE OR CITE
January 2002

2002

NARSTO Sponsoring Members

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The NARSTO PM Assessment

- What
  - A state of science for policy makers and their advisors
  - Atmospheric sciences supporting implementation of current PM standards
- How
  - 3 Phases over 2 yrs
    - ƒ Define focus with policy community
    - ƒ Inputs from scientific author teams
    - ƒ Integration/synthesis; answering policy questions

We are here

Chapters and Lead Authors

- Overview - M. Shepherd*
- Atmospheric Processes - S. Pandis
- Emissions Inventory - G. Hidy, T. Pace, D. Niemi
- Measurements - D. Hastie, F. Fehsenfeld, J. Chow
- Spatial and Temporal Characterization - C. Blanchard
- Source Attribution - J. Brook & J. Watson
- Chemical Transport Models - C. Seigneur, M.Moran
- Health - B. Jessiman, R. McClellan
- Visibility - I. Tombach, K. McDonald
- Conceptual Descriptions of 9 Regions - J. Vickery*
- Recommendations - P. McMurry*

* Co-Chairs

PM Assessment Timetable

- Internal review by NARSTO members....   10/15/01

- External review draft released to public,
     and tri-national science panel....   1/15/02

← We are here

- Review closes, comments received....   7/31/02

- Final submitted to NARSTO
     Executive Steering Committee....   10/15/02

- Document published….   12/30/02

Starting with Policy Questions; Senior Policy Maker Interviews

- 50 Senior Policy Makers
  - Federal, State/Provincial, Utility, Industry
  - US, Canada, Mexico

- 5 Themes
  - Policy goals and corresponding issues
  - Relation of science to decision making
  - Perceived areas of insufficient science
  - Presentation of uncertainties; communication
  - Drawing science conclusions & policy implications

Major messages:

- Helping answer 8 key Policy Questions will be important.
- Provide information on all spatial scales for all potentially causal species.
- Present uncertainties as ranges, as sensitivity analysis, using narrative descriptions and illustrative graphics.
- Answer the question "So What?". Do not go beyond where there is general agreement of science community.
- Having a current understanding of source contributions and transport characteristics is relevant and timely.
- Provide three versions of the report
- Don't be late! Need scientific input on an ongoing basis, but end of 2002 is ok.

Theme 1: Policy goals and corresponding issues
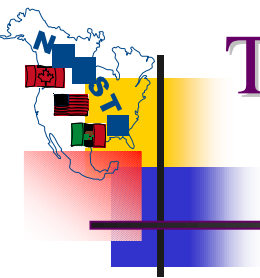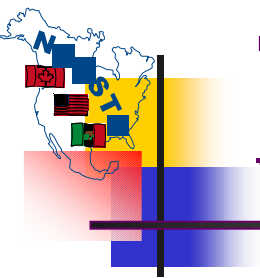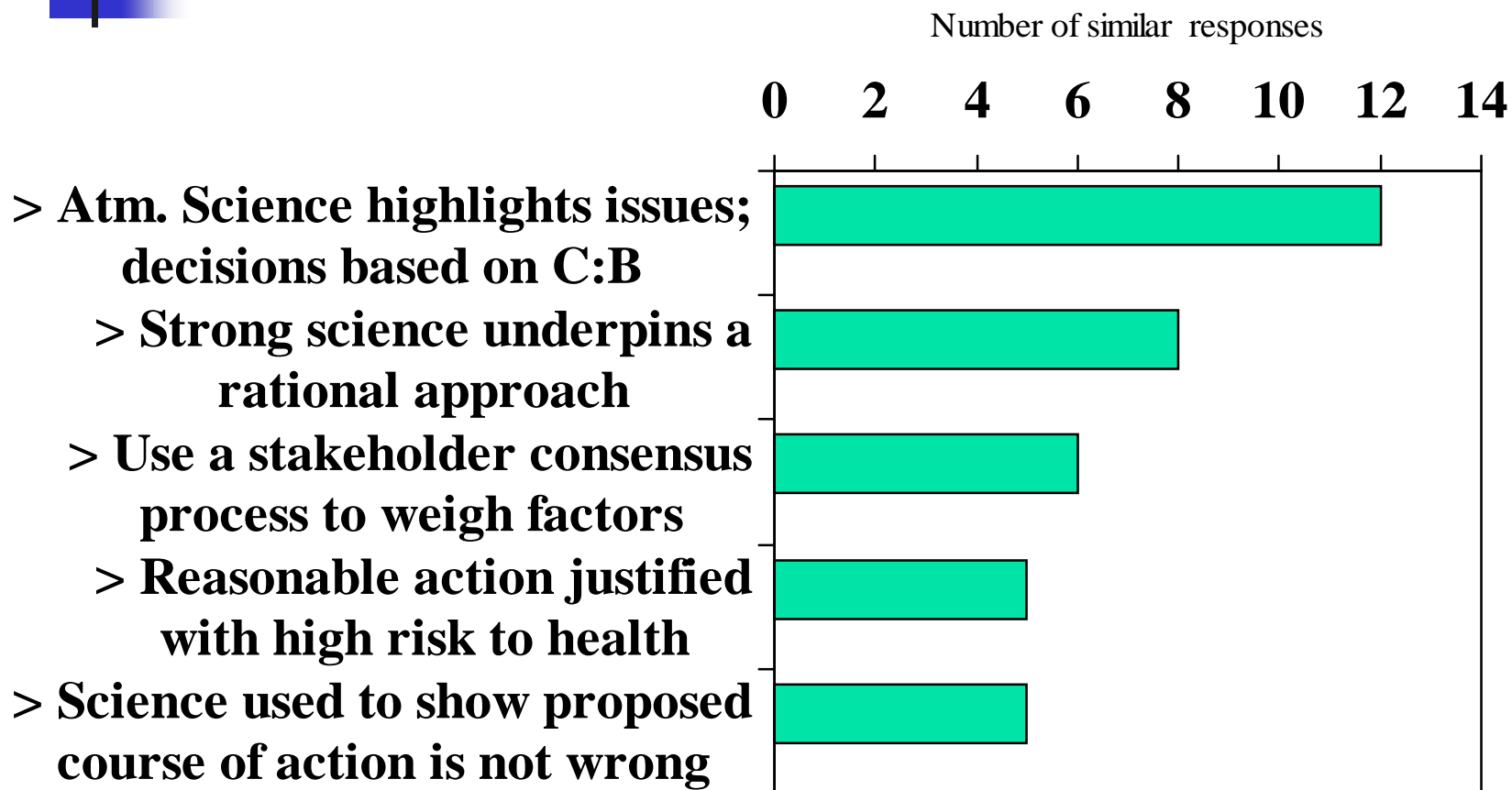
Number of similar responses
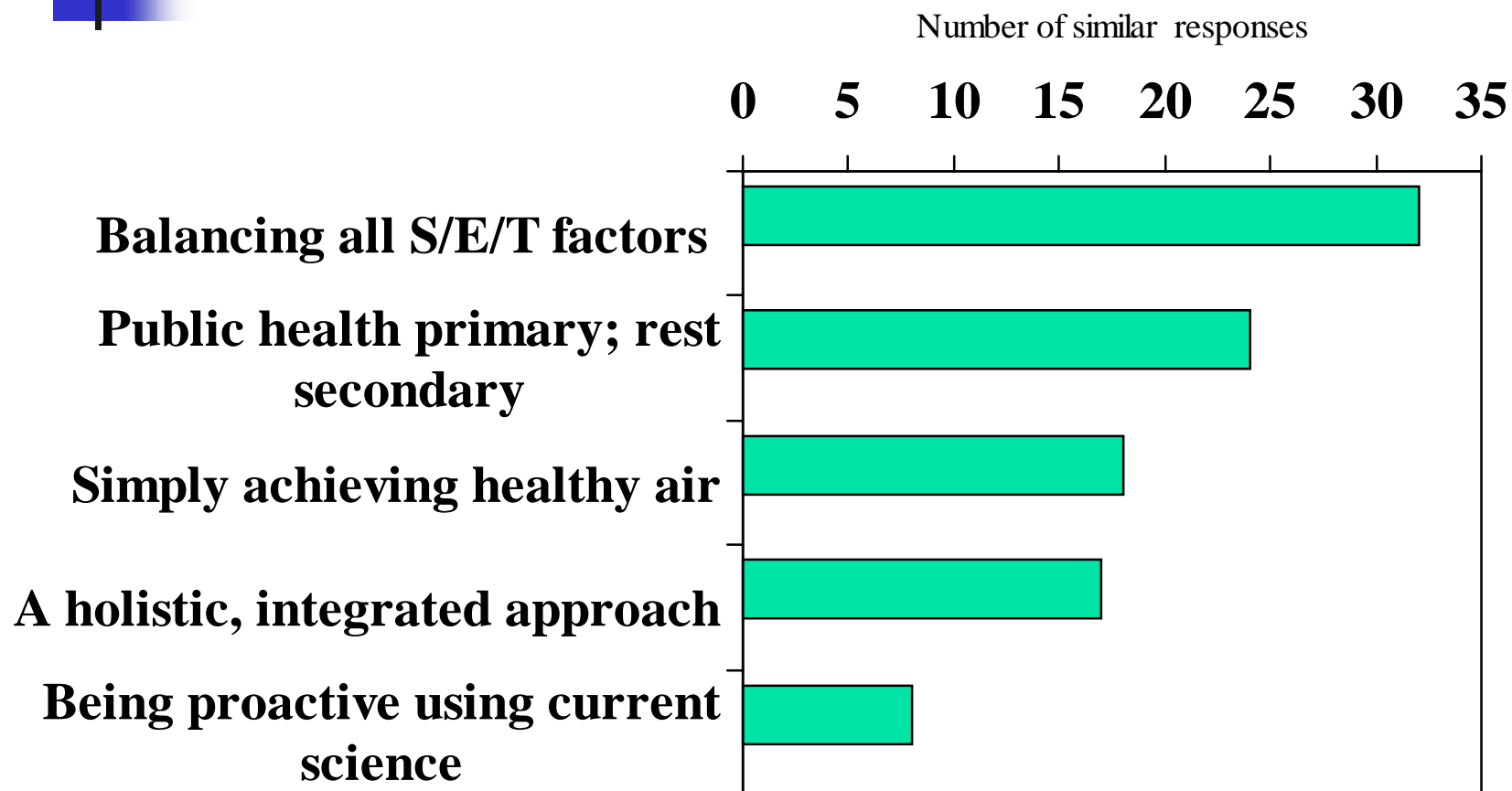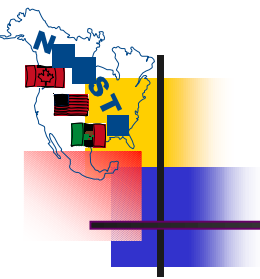
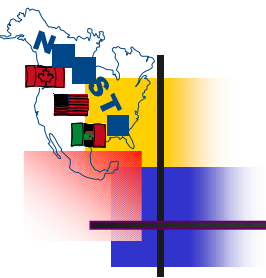# Theme 1: Policy goals and corresponding issues – Cont'd

Full agreement that having scientific answers to these 8 questions will be useful in achieving standards.

- Do we have a significant PM problem?
- What is the source of observed concentrations?
- What broad, pollutant based, approaches might fix the problem?
- What specific, source oriented, options do we have?
- What is the relation between other problems we are working on and PM?
- How can we measure progress, determine our effectiveness?
- When and how should we reassess and update our implementation programs?
- How can atmospheric science assist health and exposure studies for standards reviews?
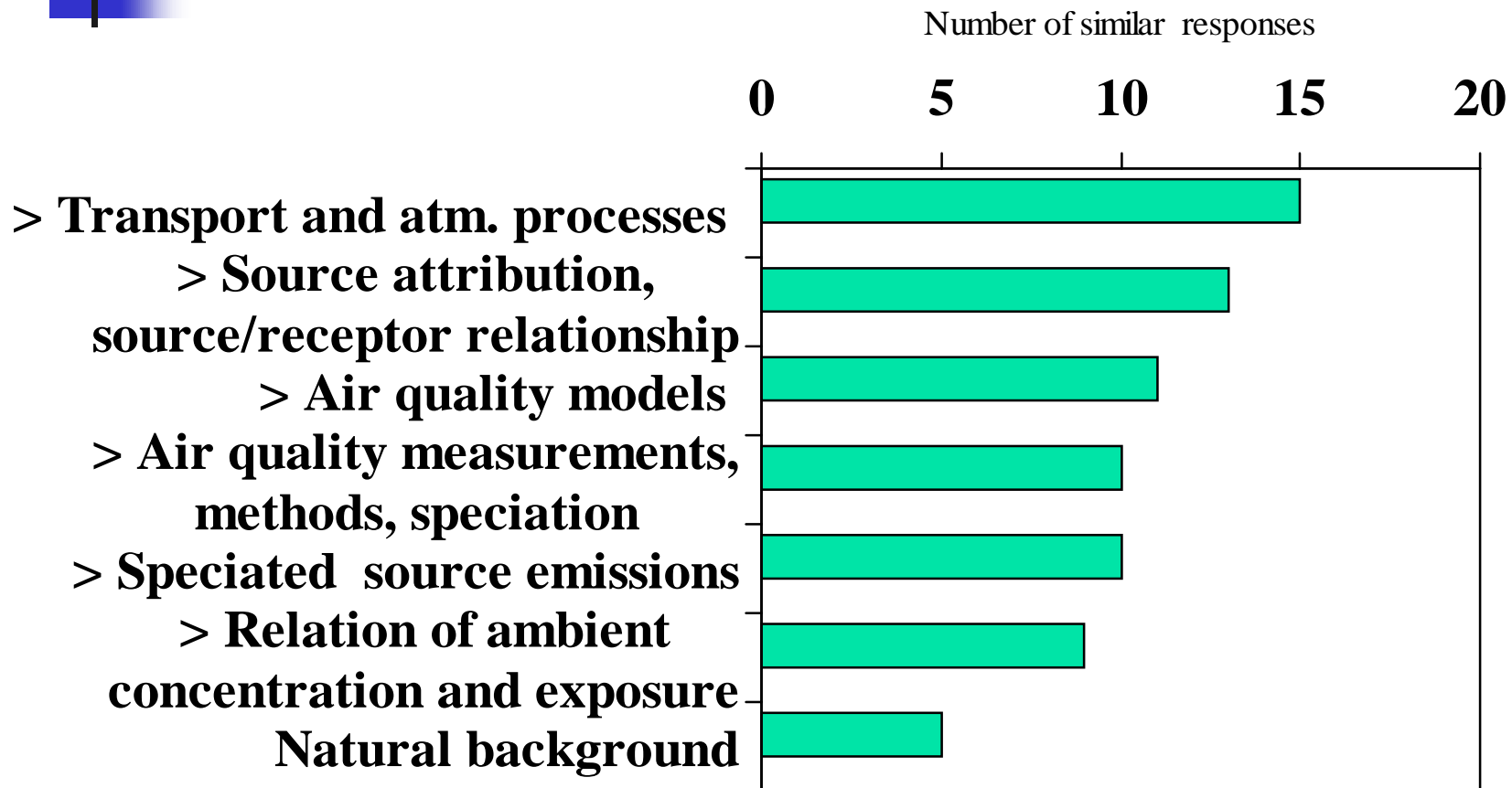
Theme 2: Relation of science to decision making – weighing science among other factors

Number of similar responses

| | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |

> **Atm. Science highlights issues; decisions based on C:B**

> **Strong science underpins a rational approach**

> **Use a stakeholder consensus process to weigh factors**

> **Reasonable action justified with high risk to health**

> **Science used to show proposed course of action is not wrong**

Theme 3: Perceived areas of insufficient science

Number of similar responses

Bar chart showing number of similar responses:
- > Transport and atm. processes: ~15
- > Source attribution, source/receptor relationship: ~13
- > Air quality models: ~11
- > Air quality measurements, methods, speciation: ~10
- > Speciated source emissions: ~10
- > Relation of ambient concentration and exposure: ~9
- Natural background: ~5

Number of similar responses

| | 0 | 5 | 10 | 15 | 20 |

> **Present a full array following a hierarchical approach**

> **Key is what communicates**

> **Scientists and staff need details for credibility**

> **Weight of evidence approach with sensitivity analysis**

> **Put in terms of broad ranges**

> **Put in terms of relative risk**

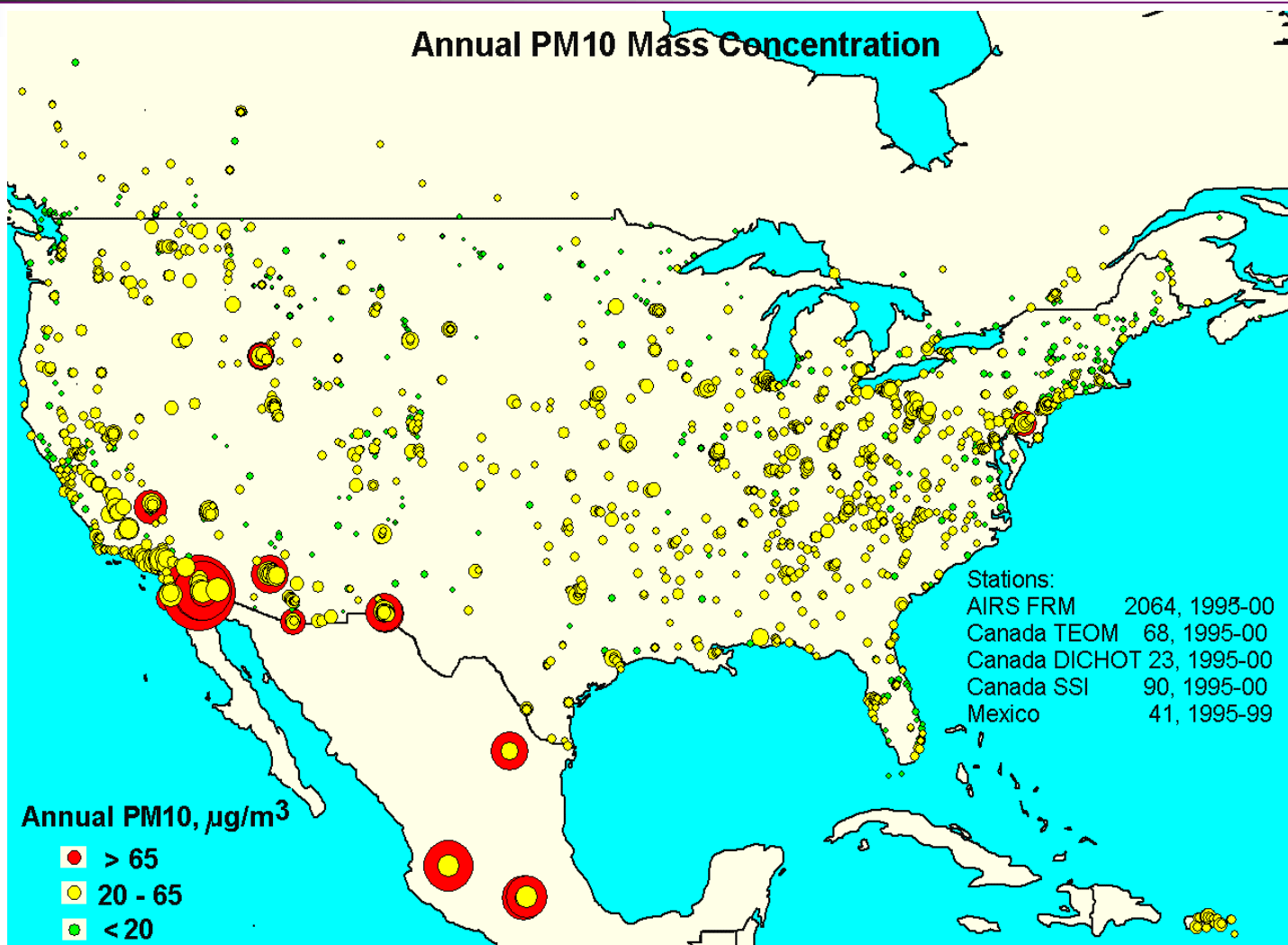# PQ#1 - Do we have a PM problem?…..
Measurement uncertainty

Table 4.3 (Abridged) Estimate uncertainty in measurements of the physical properties and chemical composition of PM.

Property	Analytic Method Uncertainty	Instrument Comparability	Time Resolution
Mass PM2.5	± 5%	± 10%	24-hr
Mass PM coarse	± 5%	± 10%	24-hr
Size Distribution (coarse, fine, ultrafine)	± 25%		5 min
Sulfate (SO_4^-)	± 5%	± 10%	3 to 24 hr
Nitrate (NO_3^-)	± 5%	± 10%	3 to 24 hr
Cloride (Cl^-)	± 10%	± 30%	3 to 24 hr
Organic Acids	± 5%	± 10%	3 to 24 hr
Ammonium (NH_4^+)	± 5%	± 10%	3 to 24 hr
Alkali Metals (Li^+, Na^+, K^+)	± 5%	± 10%	3 to 24 hr
Alkali Earth Metals	± 5%	± 10%	3 to 24 hr
Organic Carbon	± 10%	± 20%	3 to 24 hr
Elemental Carbon	± 10%	± 20%	3 to 24 hr
Total Carbon	± 10%	± 10%	3 to 24 hr
Organic Compounds (Speciated)	unknown	unknown	
Trace Elements	± 5%	± 10%	3 to 24 hr
Transition Metals	± 5%	± 10%	3 to 24 hr
Biological Aerosols	unknown	unknown	

PQ#1 - Do we have a PM problem?…..
Average annual PM$_{10}$ mass concentrations 1995-2000

Annual PM10 Mass Concentration

Stations:
AIRS FRM   2064, 1995-00
Canada TEOM   68, 1995-00
Canada DICHOT 23, 1995-00
Canada SSI   90, 1995-00
Mexico   41, 1995-99
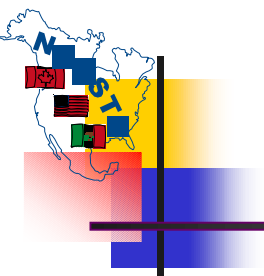
Annual PM10, $\mu g/m^3$
- 🔴 > 65
- 🟡 20 - 65
- 🟢 < 20

PQ#1 - Do we have a PM problem?…..
Average annual PM$_{2.5}$ concentrations 1995-2001
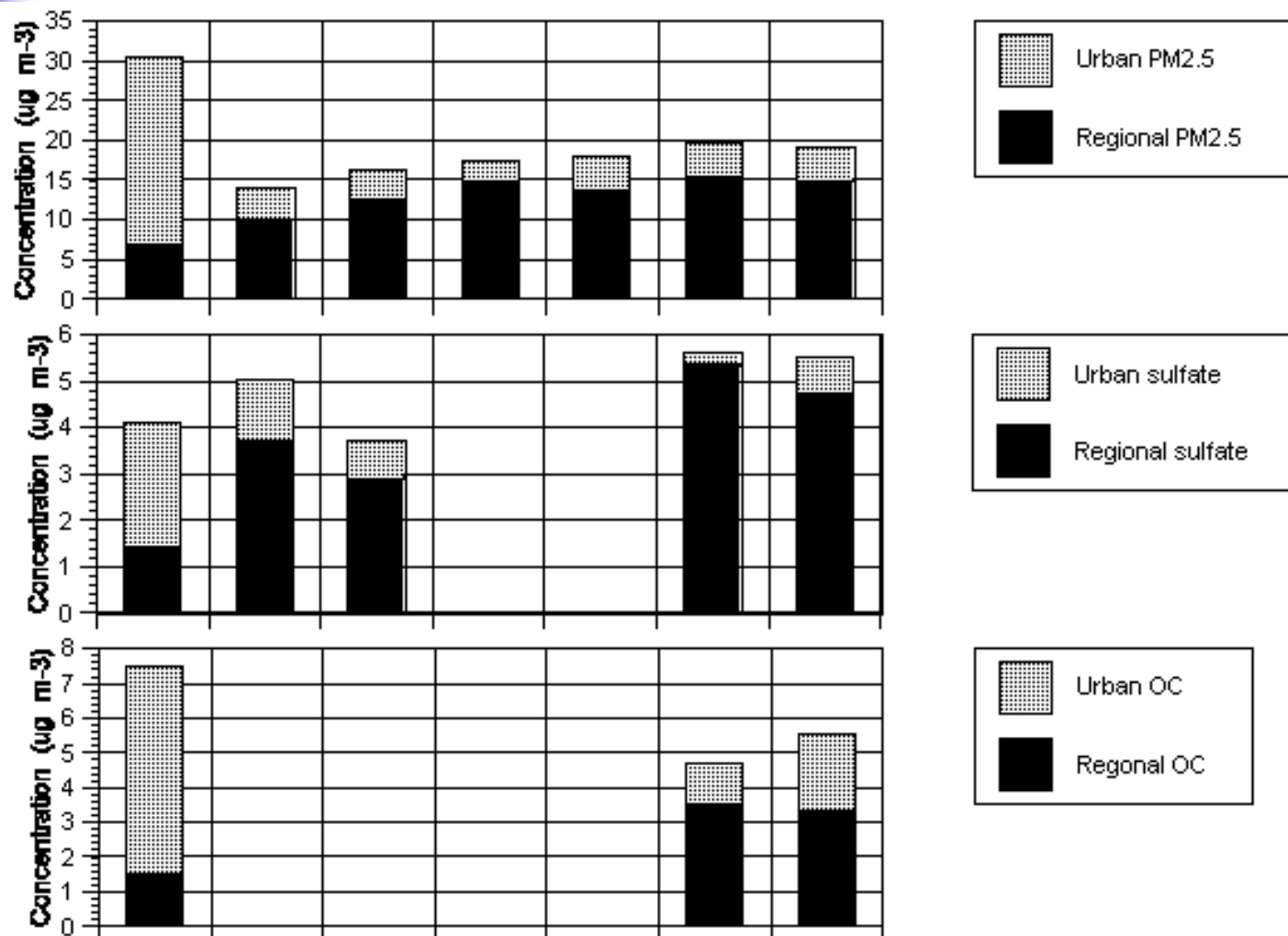### (U.S. FRM monitors began operating in 1998 and 1999)

Annual PM2.5 Mass Concentration

Stations:
AIRS FRM   1007, 1998-01
Canada TEOM   43, 1995-00
Canada DICHOT 24, 1995-00

Annual PM2.5, µg/m^3
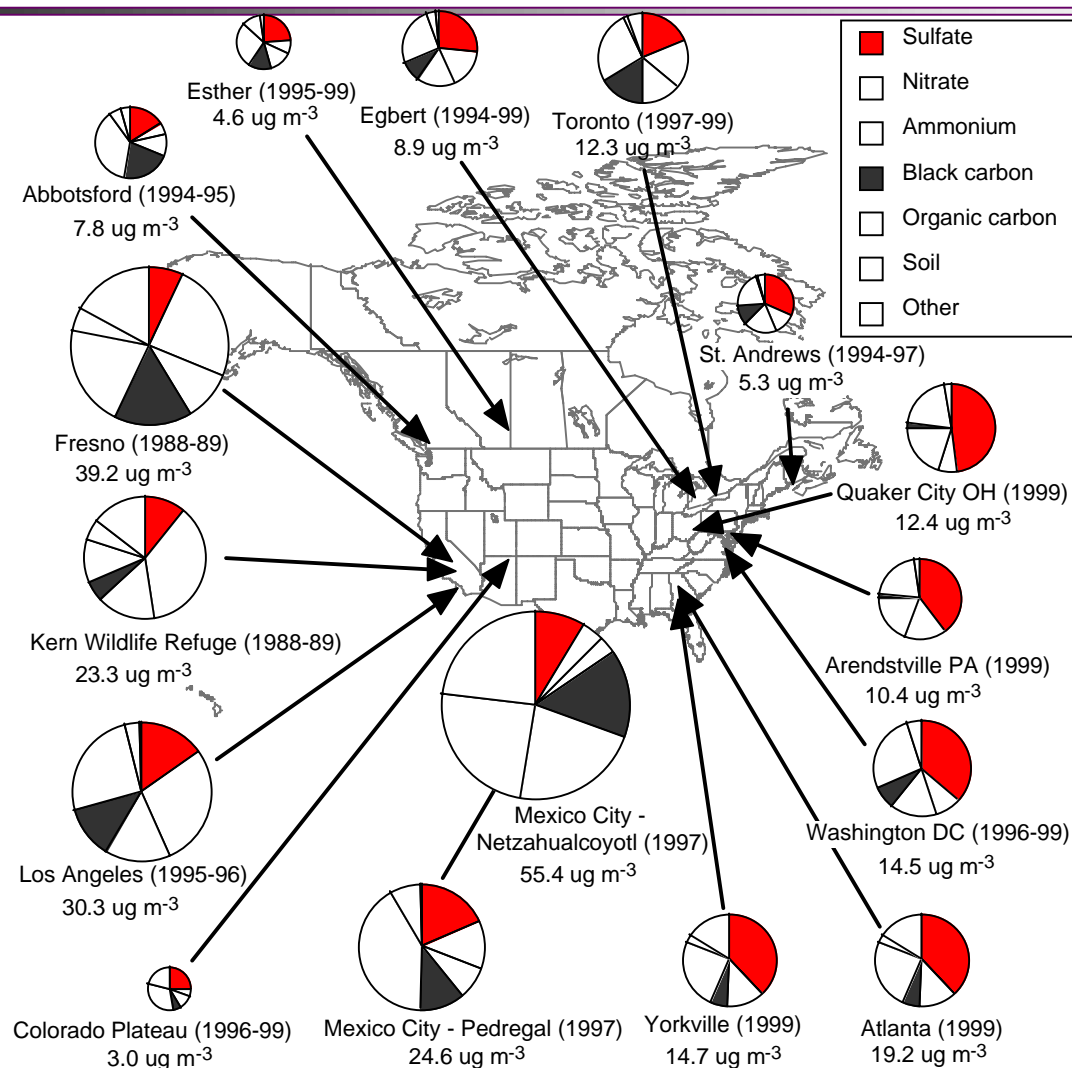- > 15
- 10 - 15
- < 10
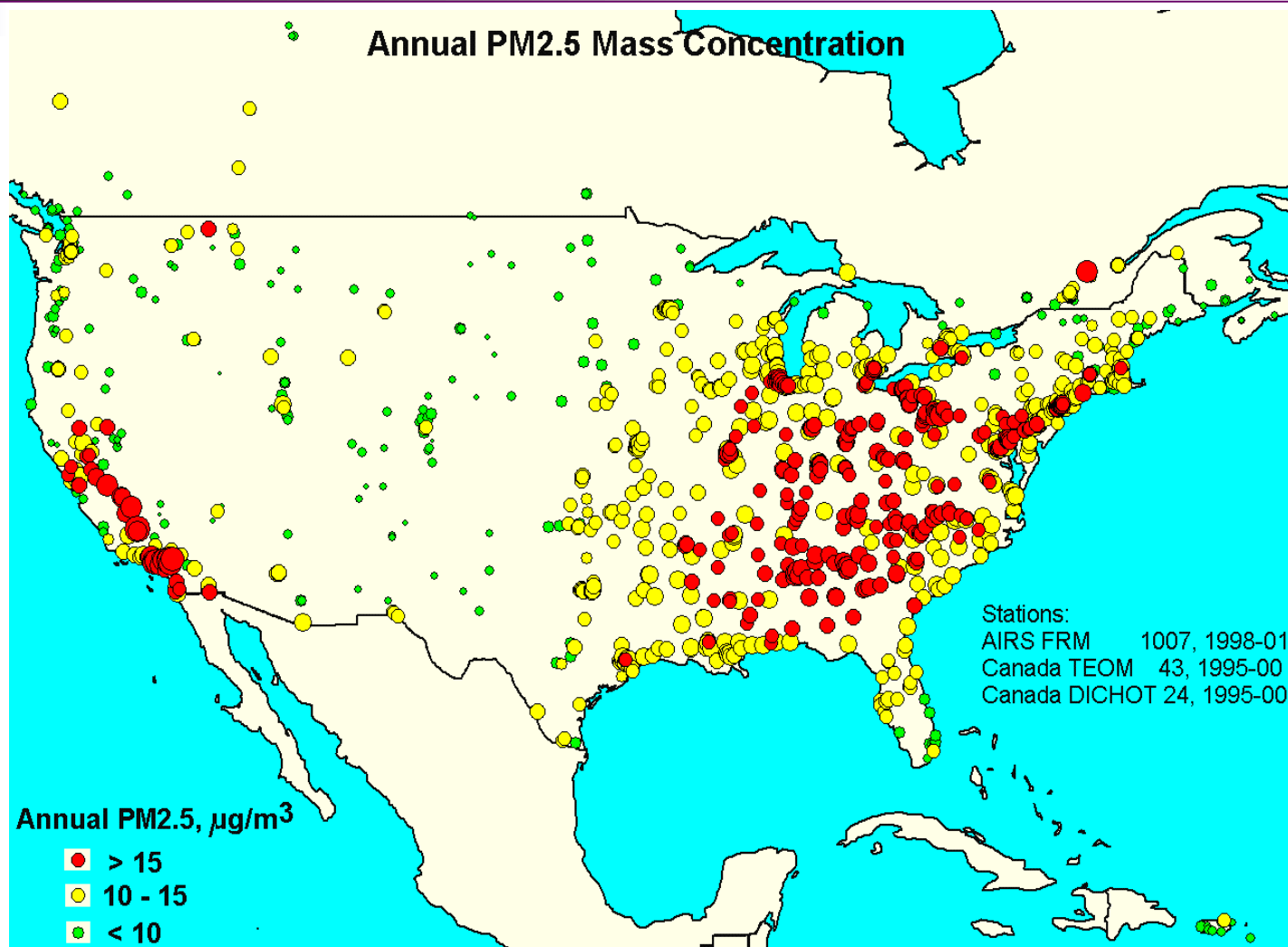
PQ#1 - Do we have a PM$_{2.5}$ problem?....
Regional vs. Urban comparisons for:
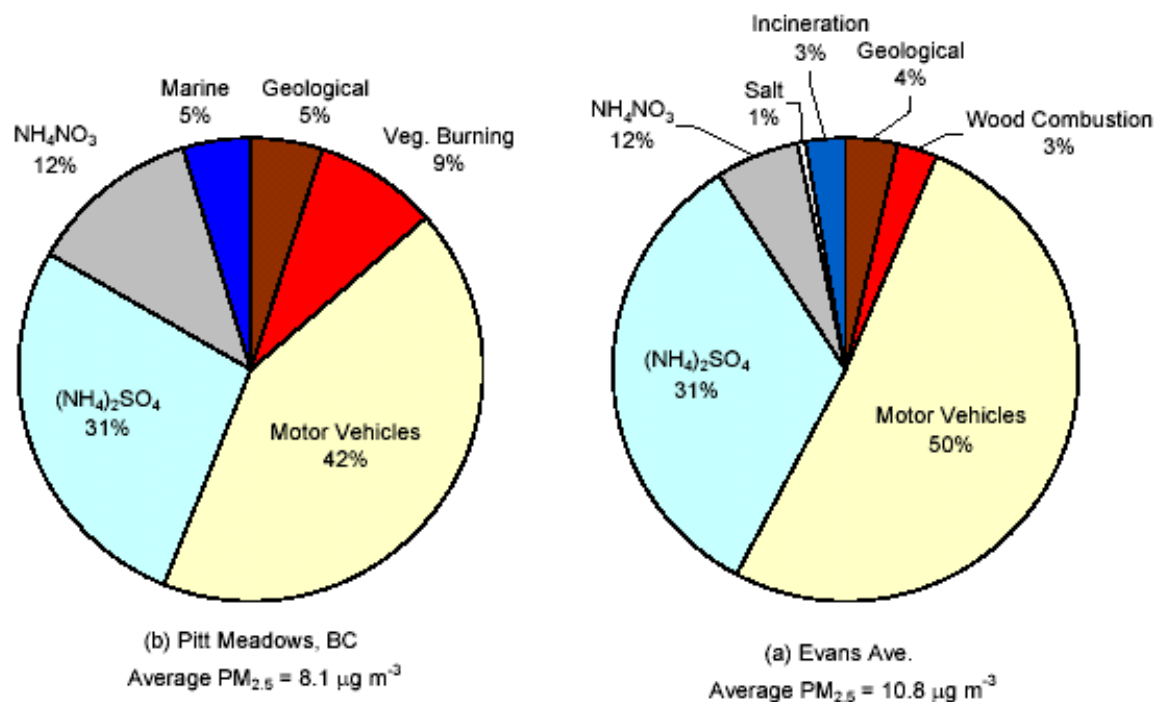(l-to-r LA, Toronto, Montreal, Wash.D.C., Nashville, Atlanta, Birmingham)

PQ#2 – Where we have a PM$_{2.5}$ problem, what is the source?…..composition

PQ#2 – Where we have a PM$_{2.5}$ problem, what is the source?…..source contribution
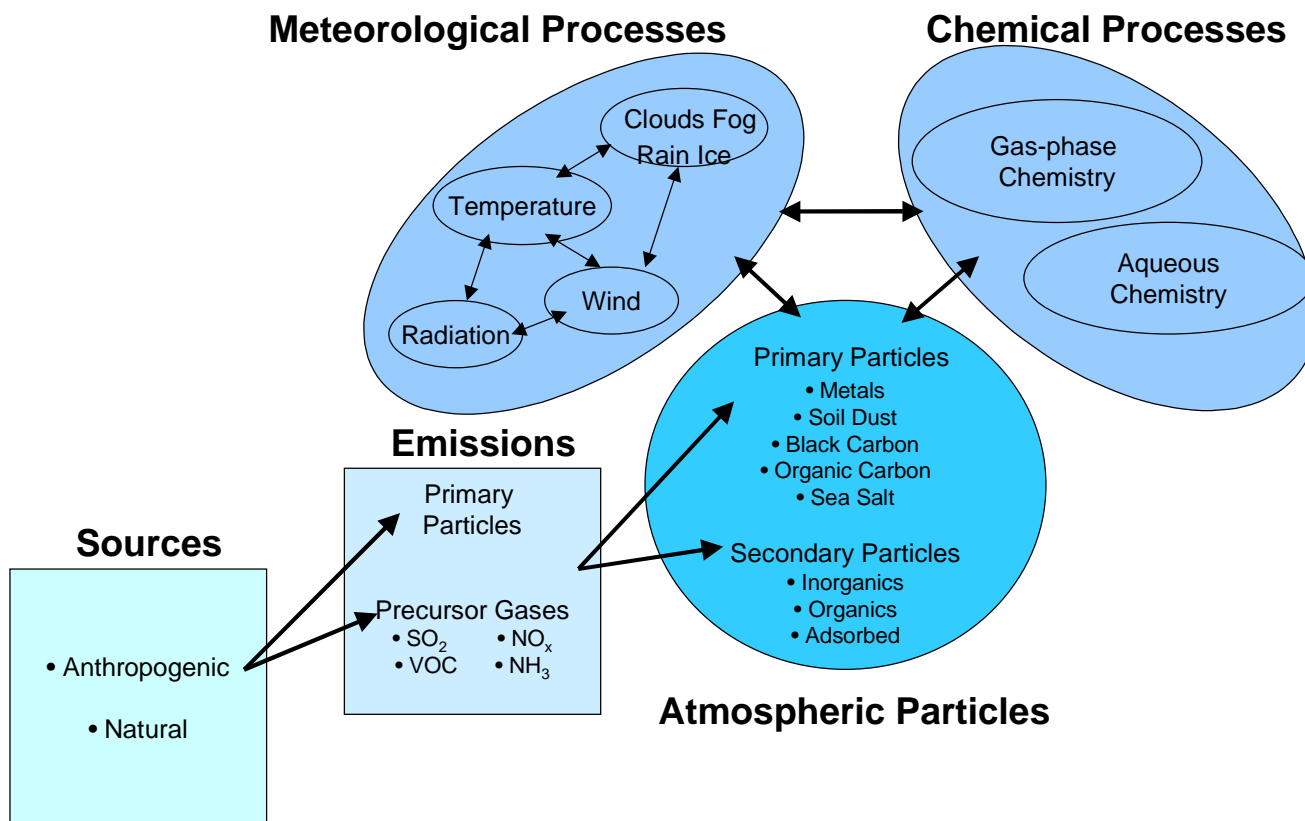
Figure PQ.3: (from Bloxam et al., 1997). CMB source contribution estimates for PM$_{2.5}$ in the Vancouver and Toronto urban areas of Canada (average for twenty-six 24-hr observations from July-August 1993).

(b) Pitt Meadows, BC
Average PM$_{2.5}$ = 8.1 µg m^{-3}

(a) Evans Ave.
Average PM$_{2.5}$ = 10.8 µg m^{-3}

Conceptual Model for Particle Matter
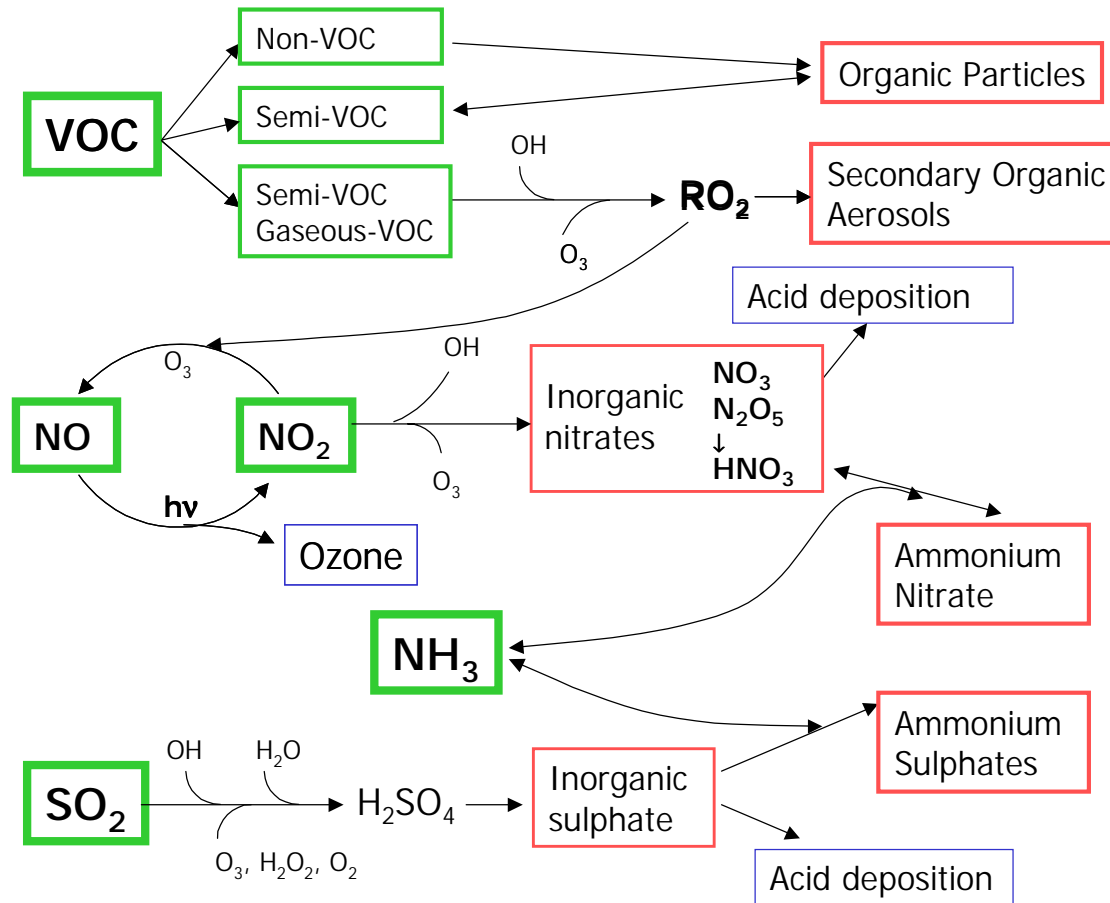
Figure 3-1 Simplified processes of particle matter formation from precursor gases
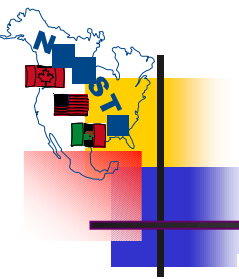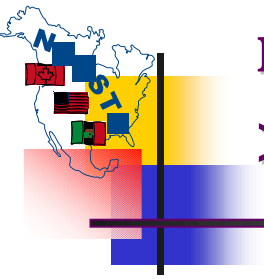
- Annual $PM_{2.5}$ levels noticeably greater than annual standard.
- Contributing maximums occur during fall and winter.
- Composition dominated by nitrate
- Fall and winter peak nitrate levels are limited by the VOC side of the oxidant process.
- Juxtaposed to the summer ozone problem that can be NOx limited.

Table 4-1 Levels of confidence in various aspect of CTM simulation

CTM Aspect	Confidence level [a]
PM Mass Components	
PM ultrafine	VL
PM fine	M
PM coarse	M
PM Composition	
Sulfate	H
Nitrate	M
Ammonium	M
OC primary	L
OC secondary	VL
BC	L
Crustal	L
Water	L
Metals	VL

	Confidence level [a]
Gases	
SO_2	H
NO_x	H
NH_3	M
VOC	M
HNO_3	M
O_3	M
Spatial Scale	
Continental	L
Regional	M
Urban	L-M
Temporal Scale	
Annual	L
Seasonal	L
Episodic	M
Forecast	VL

[a] H: high, M: medium, L: low, VL: very low
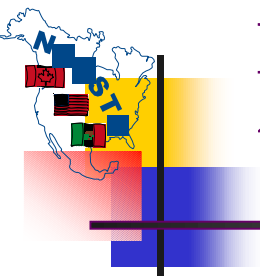
PQ#4 – What specific source options are there?….. Availability of Emissions Inventories

Table 3-10. Estimated Confidence Level of Emissions Estimates

| Pollutant	Source	Estimated Confidence Of Category in Overall Inventory		
		Canada	USA	Mexico City
SO2	Electric Utility	H	H	M
	Transportation	M	M	L
	Industrial Processes	M	M	--
	Natural	L	L	L
NOx	Electric Utility	M-H	H	M
	Transportation	H	H	M
	Industrial Processes	M	M	L
	Natural	M	M	L
VOC[1]	Electric Utility	M-H	M	M
	Transportation	M	H	L
	Industrial Processes	M	M	L
	Natural	M	M	L
NH3	Electric Utility	M	M	--
	Transportation	M	M	--
	Industrial Processes	L	L	--
	Natural	L	L	--
PM10	Electric Utility	M	M	M
	Transportation	M	M	L
	Industrial Processes	M	M	L
	Natural	L	L	L
PM2.5	Electric Utility	M	M	--
	Transportation	L	M	--
	Industrial Processes	L	L	--
	Natural	L	L	--

Table 1: Typical pollutant / atmospheric issue relationships (blank entry indicates negligible response).

Reduction in pollutant emissions	Change in associated pollutant or atmospheric issue								
	Ozone	PM Composition			Regional Haze	Acid Deposition	Climate impact	SO_2	NO_2
		Sulfate	Nitrate	Organic compounds					
SO_2		Decrease ↓	Possible increase[e] ↑		Decrease ↓	Decrease ↓	Warming ↑	Decrease ↓	
NO_x	Possible increase[a] or decrease ↑↓	Possible small increase or decrease[c] ↑↓	Decrease except special cases (e.g., SJV[f]) ↓	Possible small increase or decrease[h] ↑↓	Possible decrease or small increase ↑↓	Possible decrease or small increase ↑↓	Possible warming or small cooling ↑↓		Decrease ↓
VOC	Decrease ↓	Possible small increase or decrease ↑↓	Possible decrease or small increase[g] ↑↓	Decrease of secondary component[i] ↓	Possible decrease or small increase ↑↓	Possible decrease or small increase ↑↓	Possible warming or small cooling ↑↓		
NH_3		Possible small decrease[d]	Decrease ↓		Decrease ↓	Increase[k]	Warming ↑		
Black Carbon	Possible small increase[b]			Possible small decrease[l] ↓	Decrease ↓		Cooling ↓		
Primary Organic Compounds	Possible small increase[b]			Decrease ↓	Decrease ↓		Warming ↑		
Other primary PM (crustal, metals, etc.)	Possible small increase[b]				Decrease ↓	Increase[k] ↑	Warming ↑		

Tier I: Emissions

Tier II: Air Quality

Tier III: Exposure & Health
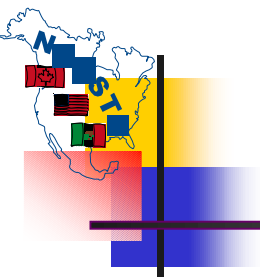
PQ#7 – When and how should we reassess and update our implementation programs?

- Emissions changes   1-3 yrs
- Ambient trends   3-5 to 5-10 yrs
- Field studies &   5-10 yrs
  Major research
- Science assessments   2-3 yrs
- Science assessment to   6-8 yrs
  policy application

- Next NARSTO PM
  assessment   End 2008
  recommended for

PQ#8 – What further atmospheric sciences information will be needed in the periodic reviews of our national standards?
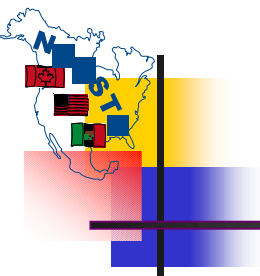
Table 8.1: Availability of Ambient and Personal Exposure Measurements for Hypothesized Causal Elements for PM - according to the separate judgments of the atmospheric science (A) and exposure (B) research communities.

Hypothesis Rationale	(A) Ambient Air Measurement Capability[a]	(B) Personal Exposure Measurement[b]
1. **Particle Mass**	Routine[c]	Routine
2. **Particle Size/Surface Area**	Research	Research
3. **Ultrafine PM**	Research	Unavailable
4. **Metals or metal compounds**	Research	Routine
5. **Acids**	Research	Research
6. **Organic Compounds**	Research	Research
7. **Biogenic Particles**	Research	Research
8. **Sulfate and Nitrate Salts**	Routine	Routine
9. **Peroxides**	Unavailable	Unavailable
10. **Soot**	Research	Routine
11. **Co-pollutants**	Routine	Routine